ENGG1500 Assessment A4 Title Page

Student number: c3339952

Discipline: Medical engineering

Workshop class: Workshop number / Day / Time

W 21/ Wednesday/ 08:00 – 10:00

Your workshop number can be found by googling ENGG1500, getting the 2020 online timetable and finding your class

Team number: 13

How many hours did this assignment take: 28 hours

What mark would you honestly give yourself: 7.5./10

Putting a low mark here will not negatively affect your mark

Compliance

Your report will not be accepted until the following list is complete

Staple in the top left hand corner (or bound)	
UoN coversheet attached to hard copy after this page. Try googling UoN cover page	
Font is 12 point Times New Roman	
*Online submission made by 3pm Monday week 9 to **BB** as a docx with the correct naming convention*	
Online submission is identical to this report	
*Submitted as a hard copy to the workshop leader **before** 5 min past the beginning of your week 9 workshop*	

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1.0 Executive Summary

The purpose of this document is to provide an interim report updating the funding body on the progress of the design and construction of a portable, wireless electrocardiogram (ECG) device. As outlined at the beginning of this endeavor, the device is designed to be used by cardiac patients, many of whom are elderly, frail or living in remote communities, minimising the need for hospital and emergency visits while maintaining a high level of cardiovascular care at home. The design team has finalised the leading design, which will be portable, transmit data via a network connection and easily implemented by the patient without professional assistance.

Although there have been some challenges especially with regard to the social distancing measures in place during the current COVID-19 pandemic and the inability of the team to meet in person, the majority of the work required to this point has been able to be conducted online. All performance criteria have been addressed and the team is now ready to begin coding the device.

The following report will provide an introduction to the ECG device, outline the constraints and assumptions made by the design team, discuss the design process and the progress towards the leading design and track the chronological milestones achieved to date.

2.0 Introduction

Since the first clinical recordings of an electrocardiogram (ECG) developed by Willem Einthoven in 1902 (AlGhatrif & Lindsay, 2012), electrocardiography has become a quintessential part of assessing patients presenting with cardiac symptoms. Although ECG devices are commonplace and available at most hospitals, they require a patient to be connected to the device by a medical professional and monitored while the reading is taken. The reading is then evaluated by physicians and cardiologists to determine a diagnosis and treatment plan. With heart disease as the leading cause of death in Australia (Heart Foundation, 2020) and the current climate of social distancing, there is a growing demand for more portable, wireless ECG devices that transmit real time data from the patient to medical professionals regardless of location. This is especially relevant to remote communities and to elderly or frail patients needing long term physiological monitoring and such devices could significantly reduce the need for hospital and emergency visits. By creating a portable ECG device, a patient is able to discretely have their heart wellbeing analysed by a nurse remotely allowing the patient to continue with their daily activities. The nurse or practitioner receives a time stamp and the signal. The device will be able to read, record, upload and backup signals from the electrodes to a cloud or save the signal as an excel spreadsheet to a OneDrive folder through the internet or mobile communications network.

2.1 Description

The Arduino Uno R3 board forms the base of the ECG device outlined in this report and, with the addition of an integrated Wi-Fi module, data can be uploaded using any network connection. The device consists of a three lead ECG monitor which reads the electrical activity generated by heart muscle depolarisation.

2.2 Scope

Remote ECG monitoring systems will soon be commonplace medical devices for monitoring patients, especially those who are elderly, frail or living in isolated locations. The device needs to be designed and built with accompanying code and additional features are optional.

3.0 Constraints and Assumptions Identified

The medical device is limited to a network connection meaning the user would require a wireless connection at home. Although more that 80% of Australian households have internet access (Australian Bureau of Statistics, 2018) and would be able to use this device with ease, it is worth noting that those in remote areas who are often in need of this type of technology are also those who are less likely to have reliable internet access. Since the device is using a rechargeable battery, the user will not be able to wear the device at all times. This window of time where the patient is not being monitored will result in limited or incomplete data and potentially increase the risk of heart problems occurring. The medical device is limited to detecting an ECG signal and producing a heartbeat in beats per minute (BPM). Other devices would have to be implemented to monitor other factors such as sleeping patterns, physical movement, body temperature and weight. The device is not waterproof and will need to be taken off for showers, again limiting the monitoring time for the patient. The device does not have a holder for it to be mounted to the patient, but the three long ECG leads means it can be placed beside them when attached.

Assumptions are based on the medical device working perfectly with all surrounding variables being ideal. It assumes the patient is willing to wear the device as much as possible and able to integrate the monitor into their lives. The patient having a constant internet connection is assumed as wireless internet connection is vital to the effectiveness of the device. A monitoring nurse or practitioner is needed at hourly intervals to receive updates of changes in the patient's heart that could be evidence of cardiac events. Since the typical patients are either elderly or frail it is assumed that they will not be participating in high intensity physical activity, giving them limited reason for having a raised heart rate. Since the battery has a limited charge it is assumed that the patient will regularly charge the battery meaning the device would have no complication performing its tasks.

4.0 Performance Criteria

Although the EGC device outlined in the report is relatively simple, there were a number of performance criteria originally developed in relation to the scope of the project and imposed by the design team.

The device should be light and portable and able to monitor the patient's heart when the battery is charged. An accurate ECG signal should be recorded and translated into a heartrate which is printed to the organic light-emitting diode (OLED) display in BPM. This process should be seamless and instantaneous. The patient should be monitored 24 hours per day, even if the device is not charged.

Since the device will be constructed in a plastic case it will need to sit beside the patient as the case is larger than what would fit securely inside a holder. The case will feature a cut out allowing the OLED screen to be seen by the patient. This is the only data released to the patient, allowing them to have a small insight into their health.

Thresholds should be put in place to determine what data is deemed to be within a dangerous level and this will be adjusted in each individual case by the cardiac team. Signals that exceed the thresholds will be sent directly to the monitoring nurse or practitioner. The thresholds are based on resting heart rate, meaning activity that increases the heart rate over the threshold will have to be determined by the monitoring nurse as real-world impacts, such as walking up a flight of stairs, are not considered in the Arduino program.

The three electrodes should be simple to self-apply by the patient and will need to be waterproof and comfortable as they are not reusable and replacements will need to be supplied if one becomes dislodged.

5.0 Design Thinking Process

The primary concern of the design team was to ensure that the ECG device constructed would be easily implemented and understood by patients without any prior knowledge of cardiovascular disease. It is important to note that, unlike those ECG machines commonly found in hospitals, this portable ECG device is intended to be used by the patient without professional assistance, and with more than half of all Australian cardiovascular disease deaths occurring in those over 85 years of age (Australia Institute of Health and Welfare, 2019) it is essential that the design be as uncomplicated as possible. Practicality, cost effectiveness and efficiency will be prioritised over appearance, see Figure 1 below. Standard ECG devices consist of 12 leads with six of those being placed on various areas of the patient's arms and legs and the remainder on the torso (Ausmed, 2018). However, this portable device is a three lead ECG monitor with the electrodes placed only on the chest, giving a full range of motion to the limbs. A reduced number of leads allows the patient to walk and do other activities while still being attached to the device and this is vital as any raised heartrate must be accounted for and monitored closely. The thresholds are based on resting heart rate so any data detected above or below the thresholds will be recorded and sent even if the data is caused by everyday activity. It will be up to the monitoring nurse to determine what the patient was doing at the specific time, which can be determined as all data uploaded will have a time stamp and can be cross referenced with the patient's daily schedule.

5.1 Discussion of Unexpected Solutions or Constraints Considered

Monitoring a heart patient in the comfort of their own home for 24 hours a day is impossible without technology. Even so, this ECG device uses a 5V portable battery which needs to be charged at least once per day and cannot be worn simultaneously while being charged. This limits the time of monitoring as the device will need to be plugged in to a power source. Due to budget constraints, the decision was made to withdraw the criteria of the device being waterproof. This, again, limits the location and time of monitoring in places with a high likelihood of contact with water, such as showering.

Originally, the device was designed to have a Bluetooth connection to a tablet/computer. This was deemed a flawed design as it was limited to a small range and required an extra device to be implemented, making the overall size too large. In order to meet the size and budget constraints, a Wi-Fi module was substituted allowing the device to connect to a network, uploading data to an online platform that can be accessed by medical professionals for analysis.

The device as it stands is already quite large as the casing has to house the Arduino, battery and other components. Although the design team had hoped to include a built-in holster, similar to that of an iPod arm or waistband, this was discarded due to the size of the casing. Since the leads are long enough, the device is able to sit beside the patient when they are sitting or in a bag when they are walking. The device is quite light allowing an elderly or frail patient to carry it with ease.

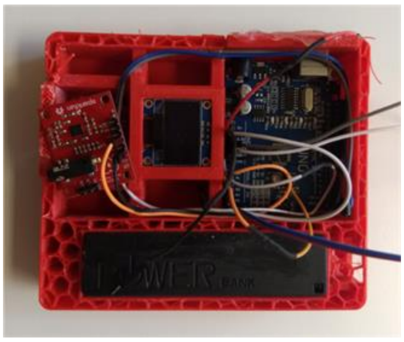


Figure 1 Original concept idea

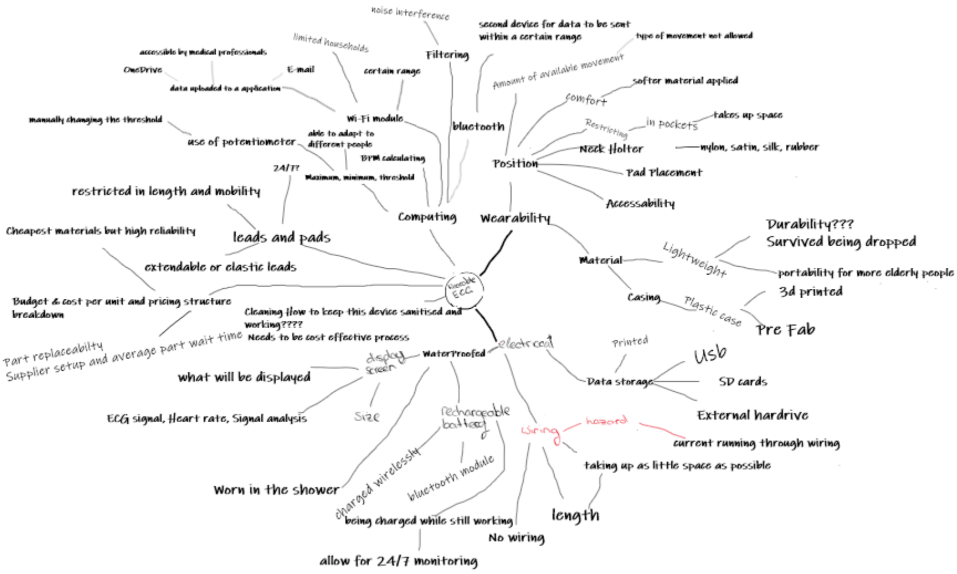


Figure 2 Current mind map showing the design thinking process

6.0 Initial Design

The initial hardware design of the wireless ECG device was intended to be used for a target audience of 60 years of age and older to monitor heart health at home and a mind map, Figure 5, was used to develop the design from this initial point. The device was originally powered by a USB cable to a computer, but the team chose to power the Arduino Uno device with a rechargeable 9V battery. The bread board provided was used to connect all of the components with wiring but without any need for soldering, see Figure 3. The team added the Bluetooth hc05 module connected to the Arduino breadboard that allows the data to be transferred and displayed on other devices without the risk of power surges or electrocution to the user. Once other components were attached, such as the heart monitor Sparkfun Ad8232 unit and leads and pads, the team was able to test the unit and collect heart data. In order to attach the device's electrodes to get the data a nonwoven fabric material was chosen. This is a type of breathable paper cotton with silver chloride gel which will give the user comfort as well as good conductive contact. The wires that connect the ECG unit to electro pads were still to be decided regarding length and placement on where to attach to the casing or device. The OLED SSD1306 display screen was added to the design to display the current heart rate to the user.

One of the most difficult design elements in this process was the external casing which will determine how the components fit together. Initial thoughts included a holder that could hang around the user's neck like a lanyard, however the relatively large size of the device is problematic. Another option was a plastic Toyogiken junction box that would house all of the components and wiring and protect it from water or moisture and also be light weight and easy to carry, see Figure 4, however the practicality of this box and how it would be carried was difficult to determine.

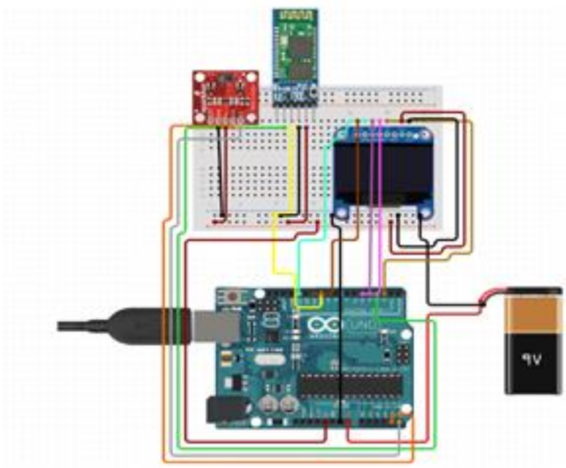


Figure 3 Basic electronic design

Figure 4 Original casing idea

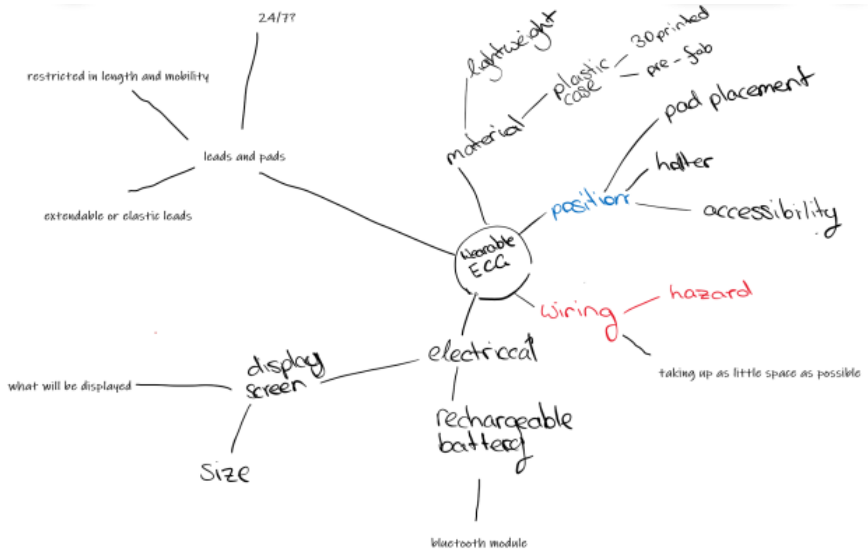


Figure 5 Original mind map

7.0 Detailed Description of Leading Design

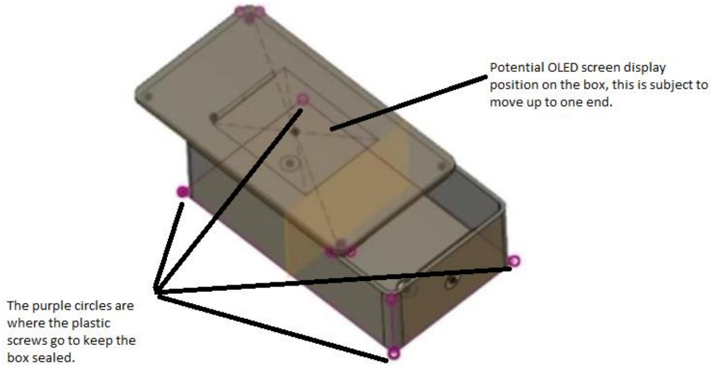
After working through many of the hurdles in designing and constructing the portable ECG device, several elements of the initial design have remained as part of the current leading design. These elements include the Arduino Uno, the breadboard, heart monitor Ad8232 unit, 9V battery, OLED display screen and all of the minor electrical components required to make the electronics work such as resistors and capacitors as well as the leads and pads.

One of the most difficult challenges to overcome has been the question of how the user would move freely throughout their daily life while carrying the device with them. The entire purpose of the ECG device was actually to make it portable and more convenient that the cumbersome devices used in hospitals which require patients to be disconnected as soon as they leave the bed. After several false starts, the leading design now features a holster with a Velcro band that can be strapped around the user's arm or mid-section with comfort and minimal impact on movement, see Figure 6.

Figure 6 Strap prototype

The second difficulty has been the design of the casing used to store all the components, which should be nonconductive, shock proof from average waist height, light weight, bright in colour so it can be found easily and nontoxic to anyone who comes into contact with this device. During one of many brainstorming sessions, the team hit on the idea of children's Duplo material as inspiration. The result is the idea of building the casing from 3D printed ABS plastic which will meet the casing scope and is very cheap to create. The final size of L90mm x W120mm x D100mm, see Figures 7, 8 and 9, can be printed in standard commercially available 3D printers without difficulty.

Figure 7 Casing viewed from below



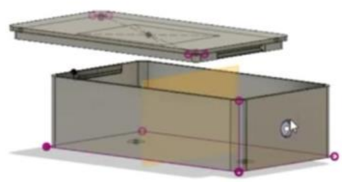


Figure 8 Casing viewed from above Figure 9 Casing viewed from side

After finalising the casing, the team was required to make an adjustment to one additional part of the design, being the Bluetooth hc05 module that connects to Arduino board with the ESP8266-01 Wi-Fi module. This will allow real time monitoring and have the capability of sending a message to the monitoring nurse and/or general practitioner alerting them if the heartrate has moved outside the acceptable range and for how long that abnormality occurred. The team intends to be able to automate this function so that it can occur in real time without any effort on the part of the patient, monitoring nurse or treating cardiac team.

The latest addition to the design was regarding data storage, where an SD module has been added to the unit as a backup feature. This means that the device itself will be able to store large amounts of data so if there is an issue transferring the data that has been recorded, it has also been stored onto the SD card which can be uploaded manually to a computer without any data being lost. The leading design for the electrical components can be seen in Figure 10.

At the time of writing this interim report, the team has yet to finalise any code. The software and code will be constantly updated and changed as the project moves forward, and research and development evolves.

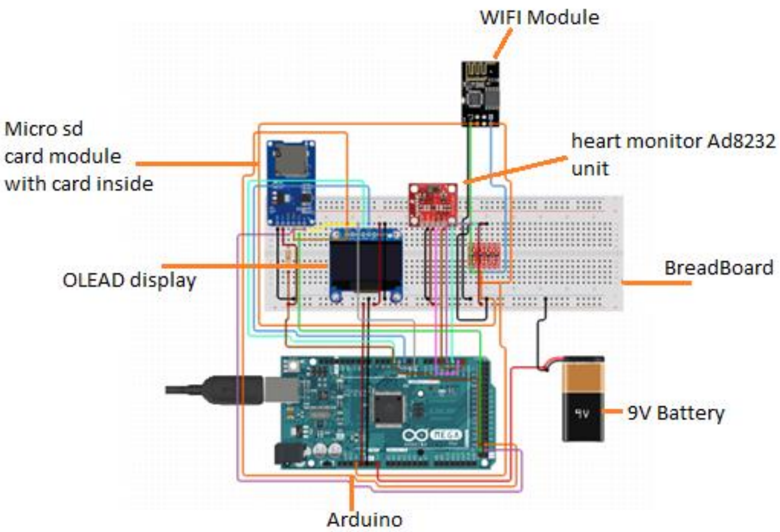


Figure 10 Electrical components

8.0 Milestones - Weeks 5 to 9

8.1 Week 5

Table 1: Milestones Week 5

Task Name:	Team member(s) responsible:	Success:
1. Understanding Limitations of ECG 2. Organising retrieval of parts 3. Receiving hardware 4. Setting team up online and becoming functional	1.William TJ Cheney 2. Stephen R Watson 3. Jaydon J Cameron 4. Stephen R Watson	Completed Completed Completed Completed
Description: ▪ Before the team built an ECG it was paramount that all members understood what an ECG was, does and what limitations it has. ▪ Having a strong team is based on strong communication and organising the team virtual and physically was the key to getting this project off the ground. All team members have done a great job from the get-go.		

8.2 Week 6

Table 2: Milestones Week 6

Task Name:	Team member(s) responsible:	Success:
1. Name the group 2. Decide on team's direction 3. Hardware setup 4. Collect heart data 5. Adding further to mind map 6. Completing Lab 6	1. All members 2. All Members 3. Jaydon J Cameron 4. Jaydon J Cameron 5. All Members 6. Stephen R Watson and Jaydon J Cameron	Completed Completed Completed Completed Completed Incomplete
Description: ▪ Deciding the name was the first crucial step to set the tone for working out what direction the team was going to head in, Thus CardiaTech was created and the team has chosen to go the commercial route. ▪ Jaydon was able to get the hardware setup and running from his home which allows up to collect our data. ▪ Heart data was able to be collected by Jaydon allowing the team to move forward with a simple basic working device letting the team evolve this design to the next level. ▪ All members were adding and discussing the mid map on a regular basis to keep ideas going as old ideas were eliminated. ▪ The team hit the first failed milestone. This goal was not achieved due to a few factors in play being a lack of understanding on how to do the task, the complexity of the task and now reflecting on it, overloading ourselves when it was not required. The team was too quick in committing to something without fully knowing what had to be done. This can be avoided in the future by understanding how much commitment is roughly required per task before taking it on.		

8.3 Week 7

Table 3: Milestones Week 7

<table>
<tr><th>Task Name:</th><th>Team member(s) responsible:</th><th>Success:</th></tr>
<tr><td>1. Read Lab 7</td><td>1. All team members</td><td>Completed</td></tr>
<tr><td>2. Develop project scope</td><td>2. All team members</td><td>Completed</td></tr>
<tr><td>3. Continue research about the heart</td><td>3. William TJ Cheney</td><td>Completed</td></tr>
<tr><td>4. Complete code for Labs 6 and 7</td><td>4. Stephen R Watson and Jaydon J Cameron</td><td>Incomplete</td></tr>
<tr><td>5. Writing a list of components</td><td>5. All members</td><td>Completed</td></tr>
<tr><td>6. Costings breakdown</td><td>6. Stephen R Watson</td><td>Completed</td></tr>
<tr><td>7. Getting Creo cad design running</td><td>7. William TJ Cheney</td><td>Incomplete</td></tr>
<tr><td>8. Heart data collected in different scenarios</td><td>8. Jaydon J Cameron</td><td></td></tr>
<tr><td>9. Data process to remove noise</td><td>9. Jaydon J Cameron</td><td>Completed</td></tr>
<tr><td>10. BPM calculated and displayed on LOED display screen</td><td>10. Jaydon J Cameron</td><td>Completed</td></tr>
<tr><td>11. Complete research and start drafting final reports introduction, history, and method</td><td>11. William TJ Cheney</td><td>Completed</td></tr>
<tr><td colspan="3">Description:
▪ Lab 6 was and 7 were not achieved during the week due to competing demands on the team’s time. Both these labs were completed in the break and shown to lab instructor.
▪ The scope was specified further with all of members adding to the design map.
▪ Research was continued into the heart regarding high and low blood pressures and contractions and relaxations of the heart muscle and how that relates to an ECG.
▪ Finally, lab seven was completed and coded and shown to lab instructors. All milestone tasks were completed for this week by all members.
▪ A list of components was completed and written up ready for the final report.
▪ A Costings guide was completed and ready to use come pitch day
▪ Setting up Creo was the second failed milestone This was due to licencing and software issues. This is still not resolved, and the team is looking at other options.
▪ Jaydon, the hardware member has collected all heart data required and was able to remove the noise and get it displaying on the OLED screen.
▪ All research has been completed by Will and the drafting process has begun.</td></tr>
</table>

8.4 Week 8

Table 4: Milestones Week 8

Task Name:	Team member(s) responsible:	Success:
1. Read and understand Lab 8	1. William TJ Cheney	Completed
2. Start setting out sections of Week 12 design report	2. William TJ Cheney	Completed
3. Create user manual for setup and instructions.	3. Stephen R Watson	In progress
4. Hardware alterations	4. Jaydon J Cameron	In progress
5. Work on min and max heart rate display.	5. Jaydon J Cameron and Stephen R Watson	In progress

Description:

- Understanding how to get output to and OLED display is crucial so the user can read its output in real time.
- The user manual will detail how to setup and use the device with no prior knowledge or experience required.
- Hardware alterations is about looking at what materials are being used and how can the team constantly improve this device at a cost-effective rate to achieve optimal performance as newer technologies are being developed.
- Minimum and maximum heart rate was assigned by the lab tutor to see if the device can show all ranges of heat beat being minimum, average, and maximum. This will be important as it will show what the heart is always doing.

8.5 Milestones weeks 9 to 12 detailing all remaining outcomes

The following tasks should be achieved between now and end of the project.

8.5.1 Labs

The team must make sure all labs are completed, and the understanding is to a high level to make the device design professional and able to perform what is required. Finishing Labs 8 and 9 is essential.

8.5.2 Code completion

All code needs to be finalised and completed with any required pseudocode for future explanation on how the device works and commenting done on the source code so if any software updates or debugging needs to be done it is very easy to understand.

8.5.3 Instruction manual

An instruction manual needs to be created so the user knows how to set up the device and ongoing device use including how to charge it safely.

8.5.4 Analysis for general performance

Complete the process of evaluating the device's testing performance to see if the team's objectives were met. If they were not, look at what needs to be reviewed to make sure it meets the scope.

8.5.5 Tinker cad model

A tinker cad or Creo style design needs to be completed so the team can show the potential clients at the end of the project all of the devices features such as design, components, how it will be used by the patient and how well the device meets the scope overall.

8.5.6 Costing

Finalise the cost of the unit showing the break down cost per device and seeing if it is viable to bring to market and be competitive.

8.5.7 hardware construction

Complete the building process so the team is able to move on to testing and make sure the device capabilities are working as promised.

8.5.8 simulated testing environments

Create a testing environment in which the device can be tested and any issues redesigned, fixed or altered to ensure the device works flawlessly.

8.5.9 overview and relevant information

All team members reading over and understanding any information the team feels is important to the project and definitely understanding the completed device before presenting the pitch of the project.

9.0 Gantt Chart

Table 5: Gantt Chart

Tasks:	Week 8	Week 9	Week 10	Week 11	Week 12
Coding commenting					
Pseudocode					
Overview and relevant information					
Instructions for use					
Instructions for setup					
Tinker cad model					
Simulated testing environments					
Costing					
Analysis for general performance					
Hardware construction					
Lab 8					
Lab 9					

10.0 Expected Performance on Test Day and Expected Rank

Based on how the team is doing so far with the current design and hardware, the design can detect data as well as display that data correctly on the OLED display. So far good choices have been made with materials and the direction the team would like to take the project. It is expected that at end of the project the design will show well thought out design concepts and a viable device model. It is difficult at this point to estimate an expected performance as the team is not able to build the actual device due to current circumstances involving Covid-19 virus and social distancing policies, however a conservative estimate would see the team scoring around 70% for the project.

11.0 References

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